SUBJECT:

Requirements for Lunar Surface TV for Apollo 16 and Subsequent

Case 320

DATE:

November 19, 1969

FROM: J. Z. Menard

### ABSTRACT

Possible functions for television in lunar exploration missions include public information broadcasts, observation of operations, and support of exploration science. MSC is currently developing a commercial frame rate color television camera for lunar surface use which appears suitable for the first two uses. Representatives of the science community have recently emphasized that for support of exploration, high resolution is of greater value than high frame rate or color. A review of candidate television cameras and communication system components indicates that the identified science requirements are most nearly satisfied by a camera similar to that proposed for the Lunar Surveying Staff. This requires a 500 KHz bandwidth, which can be transmitted to an 85-ft diameter earth receiving antenna by a portable communication system which has a 5 watt transmitter and a 30" diameter antenna, or a 2 1/2 watt transmitter and a 42" diameter antenna. A tradeoff is available between system weight, antenna size, and operating time.



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## MEMORANDUM FOR FILE

### INTRODUCTION

At the present time a requirement for television during lunar surface operations has been recognized, and MSC is procuring a high-frame-rate color camera with moderate resolution for this use. MSC is also proposing to develop a portable communication package to transmit this television plus voice and telemetry directly to earth for lunar surface operations during which communication through the LM is not available. Discussions with MSC indicate that the characteristics of this camera were chosen with PIO usage as the primary concern.

In several recent discussions of television uses on Apollo 16 and subsequent missions, representatives of the scientific community have strongly stated a desire to use television to provide support for the surface science operations and experiments. For this use they want significantly higher resolution than would be provided by the Apollo color camera, and they attach higher priority to single-frame capability (with hard-copy printout on earth) than to high-frame-rate motion rendition. To assist in consideration of this question, this memo lists some candidate functions of lunar surface TV, translates these into statements of design requirements, and makes simple tradeoff examinations of several system configuration alternatives, for the TV and communication system, using MSC preliminary estimates as input data. The functions are matters of judgment, the translation into requirements is discretionary, and the tradeoff input data is volatile, but the exercise appears to develop some useful points, and to offer a framework for discussion.

# 1.0 CANDIDATE FUNCTIONS AND REQUIREMENTS FOR TV

Figure 1 lists functions which TV might provide on lunar exploration missions and the preferred system characteristics for these usages.

(NASA-CR-107516) REQUIREMENTS FOR LUNAR SURFACE TV FOR APOLLO 16 AND SUBSEQUENT (Bellcomm, Inc.) 8 p

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2 (NASA CR OR TMX OR AD NUMBER) (CATEGORY)

Functions (A) and (B), earth-based exploration support, and exploration documentation aid, are in direct support of the lunar surface exploration operations. They place emphasis on high resolution rather than motion rendition and color. It is these functions which have recently been stressed by representatives of the science community.

Functions (C) and (D), for operations observation and PIO, have been recognized for some time, and place emphasis on high-frame rate, for motion rendition, and on color for visual interest. The current color camera development was undertaken principally for this usage, and appears well matched to the requirements. As the principal needs for motion rendition come from the operational and PIO usages, it may be acceptable to provide this capability at the LM only, using a cable-connected camera. This might ease the requirements for high bandwidth and power in the portable communications system.

Discussions of the science usages (A) and (B) indicate that a minimum effective line resolution of 500 is needed for close-up views, and the utility improves significantly as resolution is increased to 800 effective lines. There is experience from Surveyor to indicate that high resolution is also needed for panoramic and site scan usages. The varied characteristics of the science usages point to the utility, (if not the necessity) of a zoom lens and an appropriate view finder or monitor for sighting and focus. Tip, tilt and azimuth data are in the desirable category for post-flight analysis.

For the science usages, slow-scan and/or fixed-frame operations, preferably in a shuttered mode for hand-held use, appear satisfactory. Freedom from the restriction of a hard-line connection to the television camera is desirable and provision of a radio link from the camera should be considered.

The requirement for operating time of the total TV-communications package is an important parameter affecting the weight tradeoff. A six-hour voice and six-hour TV limit as suggested by MSC may be restrictive for three five-hour EVA's. A preliminary analysis of the Marius Hills traverses indicates that the tradeoff studies should extend to at least ten hours. This analysis, which may be conservative, is recorded in Figure 2.

Finally, it would be desirable for the combined TV-communication system to provide voice, backpack telemetry and all TV functions when working with MSFN stations with 85-ft diameter antennas. It appears acceptable to provide voice and telemetry and slow-scan black and white TV capability with the 85-ft stations, and a high-frame-rate color TV only when a 210-ft earth station has the moon in view.

### 2.0 CANDIDATE SYSTEMS TO MEET REQUIREMENTS

Figure 3 lists significant characteristics of some candidate camera systems and portable communication packages which might be provided in time to meet the requirements listed in Figure 1. These data have been taken from various MSC presentations and telephone responses, and may not represent current estimates. Changes in component weight estimates would introduce a fixed delta in the system weight, and changes in electrical power estimates would modify battery life and therefore the figures of weight vs operating time.

Figure 4 lists for several component combinations the effect on weight and performance characteristics of various usage times. For each combination, a step increase in weight is assumed to occur at operating times which are integral multiples of the battery lifetimes.

### 3.0 SUMMARY

- 1. The science requirements for TV can be met by a high-resolution single-frame and/or slow-scan camera, with 0.5 MHz bandwidth.
- 2. The combination in (1) can be provided at lowest weight with a cable link to a 2-1/2 watt communication package using a moderate size ( $\simeq 42$ ") antenna.
- 3. The operational flexibility of an RF camera link can be provided essentially at the incremental cost of the battery power to run the RF link and the weight penalty of utilizing two battery packages.
- 4. A significant tradeoff option is available between system weight and antenna size.

- 5. A dual-mode (high resolution or high-frame rate) camera would meet both science and PIO requirements at lowest total system weight.
- 6. If a high-resolution camera and 0.5 MHz communication package were chosen for science use on the lunar surface traverses, high-frame-rate PIO capability in the vicinity of the LM can be obtained for essentially the weight ( $\approx$  12 lb) of the color camera and cable by using the LM USB transmitter.
- 7. If high-frame-rate color television for PIO use during lunar surface traverses could be constrained to those periods when 210-ft stations on earth have the moon in view, a communication package using a 5-watt transmitter and 30" antenna (such as that appropriate to high-resolution, low-frame-rate camera to an 85-ft station) would be adequate.

203-JZM-ep

Attachments

J. Z. Menard

# LUNAR SURFACE TELEVISION

Possible Functions	Comments	Camera Characteristics
A. Real-time earth-based support for exploration  Terrain views for location of LM, rover, EVA  Views of science sites for discussion  Close-up views of samples for consultation  Data to discuss planning modifications	Strong support expressed by geologists and astronauts	High resolution ( ≥ 500 lines) Low frame rate Zoom lens Available at LM, rover, EVA Good mobility for EVA use Shuttered mode preferred Color not needed
B. Documentation aid to increase exploration efficiency Exploration site record Sample location orientation	Film camera is alternate	
C. Assistance with operational problems Deployment of rover, and experiments Hardware anomalies	No requirement identified  Might be occasionally useful	Preferred High frame rate (≥20 FPS) Resolution ≥ network TV Zoom lens Available at LM, rover, EVA
D. PIO Broadcasts Activities around LM Activities around rover Lunar scenes Sample close-ups	No formal requirement identified  General agreement that function must be provided	Possibly acceptable operation only at LM Slow-scan or stills Black and white

### Assumptions:

- 1. Continuous voice/TM capability
- 2. TV at sites and during overhead time (antenna pointing problem while riding)
- 3. 6 hour time from depress to repress
- 4. Line of sight means LM (not antenna) is in view and within 5 km.

Typical traverse:					(6 hour suit	limit)	ı
	LRV 5 km/hr.				LRV 10 ki	m/hr.	
Overhead	1.5 hrs.				1.5 hrs		
Science	2.0				2.5		
Travel	2.5				2.0		
For tradeoff purposes use:							
	Overhead		1.5 hrs.				
	Science		2.25				
	Travel		2.25				
Marius Hills							
	Traverse 1 (west)		Traverse 2 (south)		Traverse 3 (east)		
Within line of sight of LM (inc. overhead)	2.25 hrs.		3.0 hrs.		4.75 hrs.		
TV through cable* (overhead)	1.5		1.5		1.5		
TV through portable comm. relay*	2.25		2.25		2.25		
Voice/TM through LM relay	2.0		2.25		3.25		
Voice/TM through portable comm. relay	4.0	+	3.75	+	2.75	=	10.5 hrs.

<sup>\*</sup>If TV during overhead requires distances which preclude use of cable, TV through portable comm relay increases accordingly - max 3.75 hrs.

TELEVISION USAGE DURING MARIUS HILLS TRAVERSES.

# CANDIDATE SYSTEM COMPONENTS

Camera System					
	Input Watts	Weight Lbs	Bandwidth MHz		
LSS + cable 800 lines 0.625 FPS Shuttered Black and White	10	8			
LSS + RF link	12	10*	0.5		
Apollo 11 + cable 500 lines 0.625 FPS Non-shuttered Black and White  220 lines 10 FPS	6	8			
Apollo color + cable 175/350 lines 30 FPS	10	13			
Apollo B&W + cable	9	12	2.0		

Communication System						
	Input Watts	Output Watts	Antenna Inches	Weight Lbs		
0.5 MHz Suitcase	23	2.5	42	42**		
	45	5	30	41**		
2 MHz Suitcase	45	5	60	45**		

<sup>\*</sup>Weight with 2 lb battery, providing 6 hours LSS operation \*\*Weight with 8 lb battery, providing 320 watt/hours

# SYSTEM OPTIONS

		·				
Configuration	Hours Battery	Wt with 1 Battery	Wt for 10 hours	Wt for 15 hours	Comments	
LSS + cable 2.5 watts 42" antenna	9.7	50	58	58	Low Weight Moderate Antenna	Good Science
LSS + cable 5.0 watts 30" antenna	5.8	50	58	66	Moderate Weight Small Antenna	
LSS + RF 2.5 watts 42" antenna	14.0	52* 58**	54*	64*	Moderate Weight Moderate Antenna	Best Science
LSS + RF 5.0 watts 30" antenna	7.1	51* 57 **	61* 65**	71*	High Weight Small Antenna	& Mobility
Apollo 11 + cable 2.5 watts 42" antenna	10.3	48	48	56	Low Weight Moderate Antenna	Dual Science
Apollo 11 + cable 5.0 watts 30" antenna	6.0	47	55	63	Moderate Weight Small Antenna	Science & PIO
Color + cable 5.0 watts 60" antenna	5.8	58	66	74	High Weight Large Antenna	Best PIO
Color + cable LM USB	NA	13	13	13	Lowest Weight LM only use	Good PIO

<sup>\*</sup>LSS camera includes 2 lb battery with 6 hour capacity

<sup>\*\*</sup>LSS camera includes 8.5 lb battery with 26 hour capacity

## BELLCOMM, INC.

Subject: Requirements for Lunar Surface TV From: J. Z. Menard for Apollo 16 and Subsequent

Case 320

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